Idaho State Department of Agriculture
Division of Agricultural Resources

# Ground Water Quality of Minidoka County Basalt Aquifer

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## Introduction

The Idaho State Department of Agriculture (ISDA) developed the Regional Agricultural Ground Water Quality Monitoring Program to characterize degradation of ground water quality by contaminants leaching from agricultural sources. The ISDA currently is conducting monitoring at eleven regions in Idaho, including a project in Minidoka County (Figure 1). The objectives of the program are to: (1) characterize ground water quality, primarily related to nitrate-nitrogen ($NO_3$-N) and pesticides, (2) determine if legal pesticide use contributes to aquifer degradation, (3) relate data to agricultural land use practices, and (4) provide data to support Best Management Practices (BMP) and/or regulatory decision making and evaluation processes.

The ISDA Minidoka regional monitoring project began in 1997 as a result of previous monitoring by the Idaho Department of Water Resources (IDWR). To establish this regional monitoring project, the ISDA randomly selected domestic wells in the area and coordinated with homeowners to conduct ground water sampling.

Nutrients, pesticides, and common ions were evaluated during the four years (1997-2000) of ISDA's testing, and pesticides were evaluated during 1997 and 1999. Laboratory results indicate that numerous domestic wells northwest of Paul and northwest of Rupert have $NO_3$-N levels that suggest some type of land use influences on the ground water. Increases in year-to-year median $NO_3$-N concentrations also are evident. The exception was 1999 when the median $NO_3$-N concentration was the lowest out of the four sampling years. Low level detections of various pesticides were found in numerous wells sampled during 1997 and 1999.

The ISDA is currently working to advise residents and officials of the area on how to minimize further ground water contamination and possible health risks. Ground water monitoring will continue at least through the year 2001 to assist with these efforts.

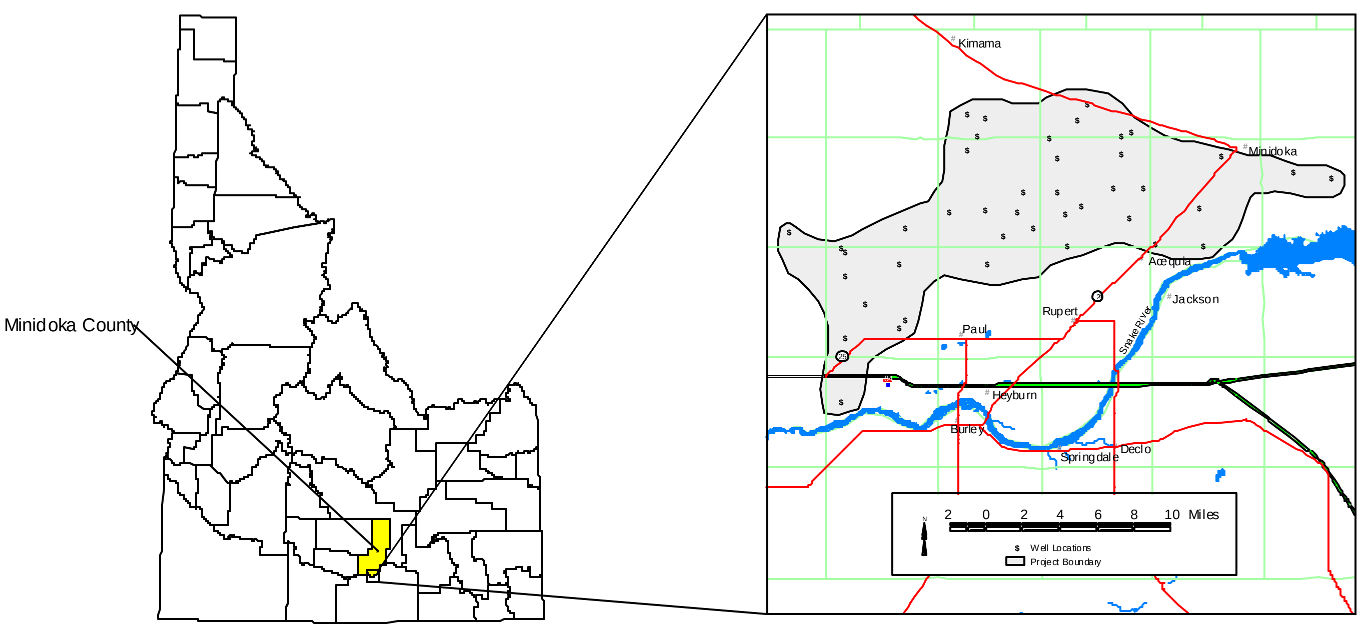



**Figure 1.** Location of ISDA Regional Agricultural Ground Water Quality Monitoring Program study area in northern Minidoka County.

## Description of Project Area

The Minidoka regional project encompasses approximately 450 square miles of irrigated agricultural land north of the Snake River (Figure 1). The majority of the land use is agricultural with only a few dairies located within the project area (Rupert, 1997). The area depends on both surface water from the Snake River and ground water from the Eastern Snake River Plain Aquifer for irrigation (Rupert, 1997; Mitchell, 1998). Local irrigation systems vary from the typical and historic practice of flood irrigation to more modern techniques of sprinkler irrigation. Major crops include alfalfa, potatoes, sugar beets, wheat, barley, corn, and beans (Mitchell, 1998). The soils are sandy and drain well to excessively (Rupert, 1997). The sandy soils overlie a basalt aquifer that serves as a regional water source for a variety of uses, such as Bureau of Reclamation production wells, rural domestic water supplies, public water supplies, and irrigation wells.

Potential sources for $NO_3$-N leaching to ground water in the area include applied nitrogen-based fertilizers, septic systems, cattle manure, legume crops, and nitrogen mineralization. A study conducted by Rupert (1996) calculated that 93% of the total $NO_3$-N input into the Eastern Snake River Plain regional system is supplied by cattle manure (29%), fertilizer (45%), and legume crops (19%). He also concluded that domestic septic systems had minimal $NO_3$-N input (less than 1%) and precipitation provided 7% of the $NO_3$-N input.

## Hydrogeology

The top soil in the project area can be classified into three basic types. The soil north of the Snake River and South of Paul and Rupert is somewhat poorly drained loamy sands to clay loams on low alluvial terraces (Hansen, 1975). The soil north of Rupert and south of Acequia is classified as well drained sands and fine sandy loams on basalt plains (Hansen, 1975). The soil north and west of Acequia is well drained silt loams on basalt plains (Hansen, 1975). The mixture of clay, silt and top soil extends between 2-50 feet below the ground surface (Figure 2).

The basalt aquifer that underlies the top soil and clay layers is a portion of the Eastern Snake River Plain Aquifer (ESRP Aquifer). The ESRP Aquifer is a regional source of water and the aquifer from which the samples for this project are taken. Rocks of the ESRP Aquifer are made up primarily of a series of vesicular and fractured basalt flows of the Snake River Group and generally are less than 100 feet below the ground surface in the project area (Figure 2). Well drillers' reports of wells included as part of this project indicate static water levels typically between 150-300 feet below ground surface, with a median value of approximately 206 feet (Figure 2).

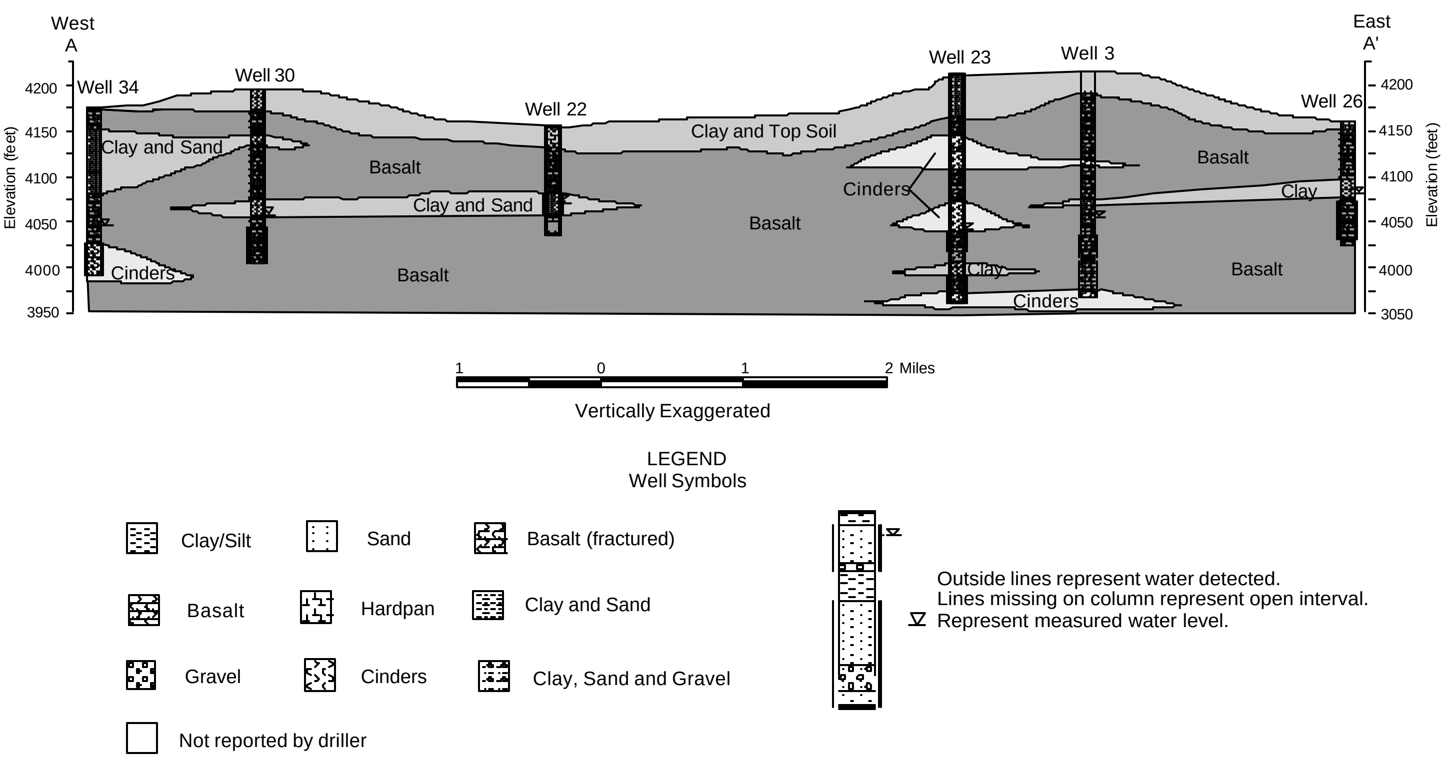



**Figure 2.** Geologic cross section based on well drillers' reports from North Minidoka project area. Cross section line is displayed on Figure 3 (page 3).

During March 1980, approximately 1,600 static water-level measurements of the ESRP Aquifer were taken by the U.S. Geological Survey (USGS) (Lindholm et al. 1983). The static water-level measurements were used by Bendixsen (1996) to determine the direction of horizontal ground water flow of the ESRP Aquifer by contouring measurements using Surfer™ computer software (Figure 4).

Ground water movement of the ESRP Aquifer is generally from the Northeast to the Southwest as seen in Figure 4. The Snake River area is a discharge point of ground water from the ESRP Aquifer via spring flow and seepage between Milner Dam and King Hill (Rupert, 1997).

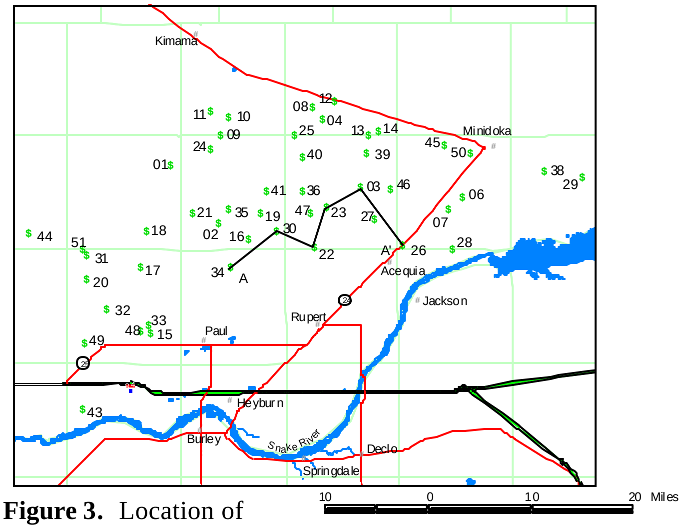



**Figure 3.** Location of wells monitored by ISDA from 1997 to present. The map also shows cross section line for Figure 2.

**Figure 4.** Potentiometric surface map of the ESRP Aquifer in the project area.

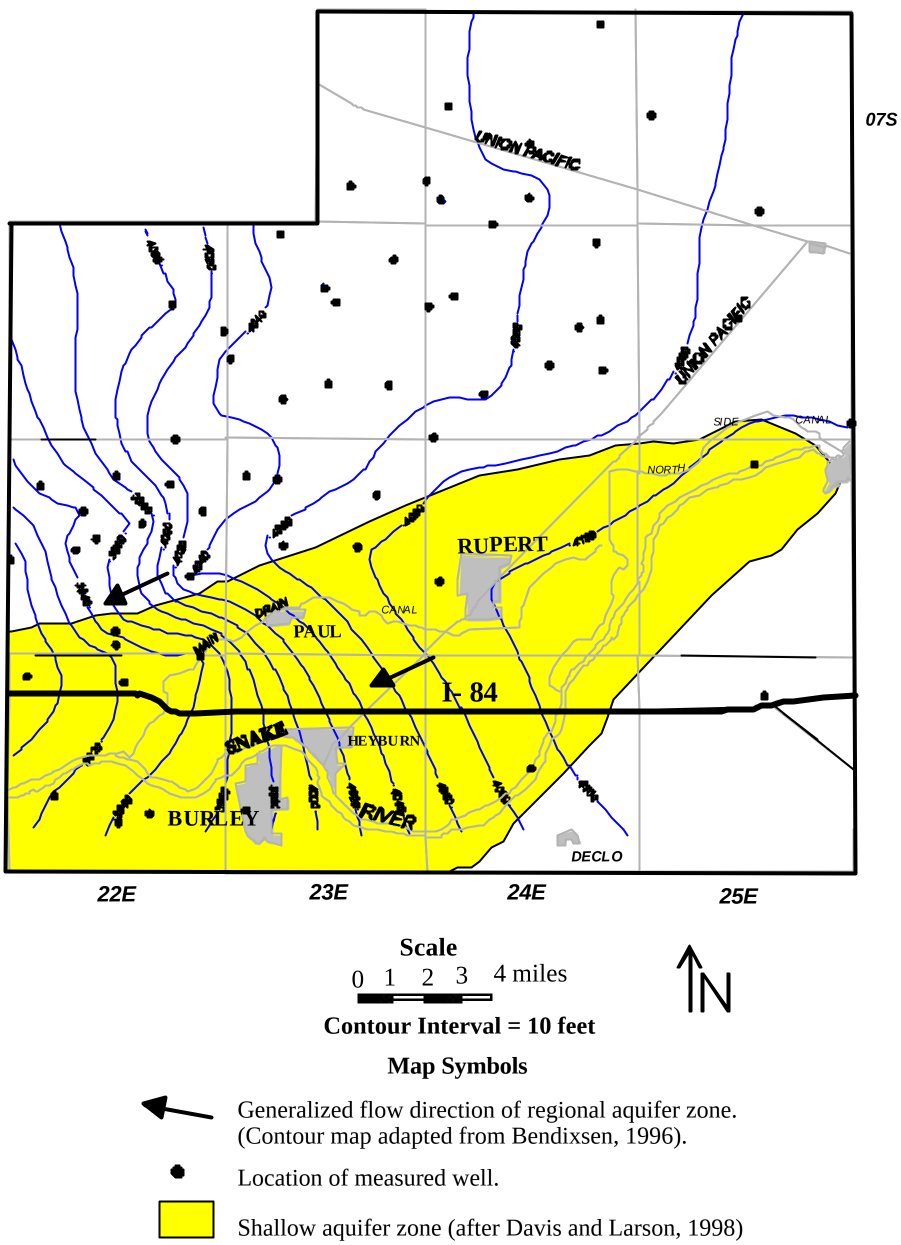


**Table 1.** $NO_3$-N results for North Minidoka project.

| Concentration Range (mg/L) | 1997 48 Wells | 1998 48 Wells | 1999 48 Wells | 2000 48 Wells |
|---|---|---|---|---|
| <*LDL | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |
| *LDL to <2.0 | 4 (8%) | 8 (16%) | 12 (25%) | 11 (23%) |
| 2.0 to <5.0 | 24 (50%) | 20 (42%) | 20 (42%) | 17 (35%) |
| 5.0 to <10.0 | 20 (42%) | 20 (42%) | 16 (33%) | 20 (42%) |
| >10.0 | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |
| Median Value | 4.1 | 4.21 | 3.84 | 4.51 |
| Maximum Value | 7.8 | 8.53 | 8.50 | 9.09 |

*Laboratory Detection Level

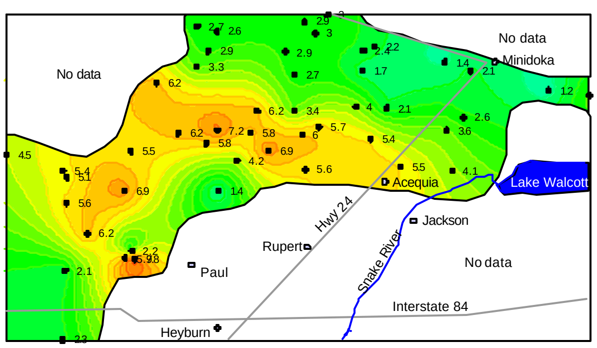
# Results

Sampling results for the four years of testing show $NO_3$-N and pesticide detections in the ground water. Results are summarized and presented in the following sections.

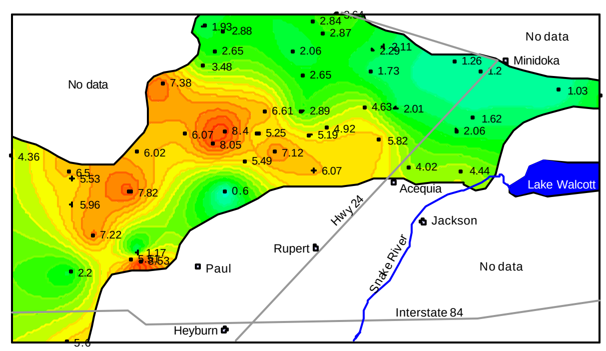
## Nitrate

Results of ground water sampling in the project area from 1997 to 2000 are shown on Table 1. The data indicate increases in median $NO_3$-N levels, with an exception in 1999, which had the lowest median $NO_3$-N value during the four years. During the four sampling rounds, there have been no detects of $NO_3$-N over 10 milligrams per liter (mg/L), which is the EPA Maximum Contaminant Level (MCL). In 2000, 20 or 42% of the wells had $NO_3$-N concentrations with the range of 5 to <10 mg/L (Table 1). This is consistent with sampling years 1997 and 1998. However in 1999, 16 or 33% of the wells had concentrations within this range (Table 1). The highest detected concentration level was 9.09 mg/L, occurring during the 2000 sampling round (Table 1).

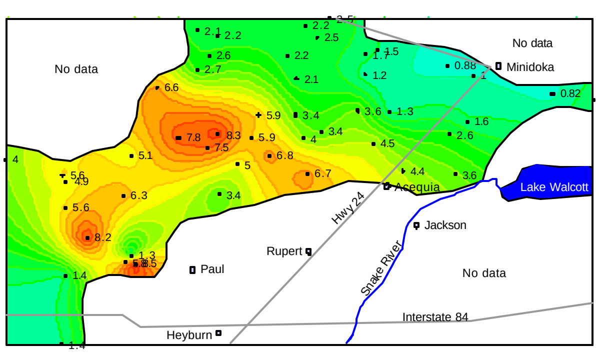
Contouring of $NO_3$-N was completed to spatially evaluate concentrations (Figure 5). Contouring indicates elevated levels of $NO_3$-N (areas that are red) in two main locations: one northwest of Paul and one northwest of Rupert. The elevated levels of $NO_3$-N appear to have increased in geographic extent, as can be seen when comparing the 1997 map to the 2000 map. The areas of



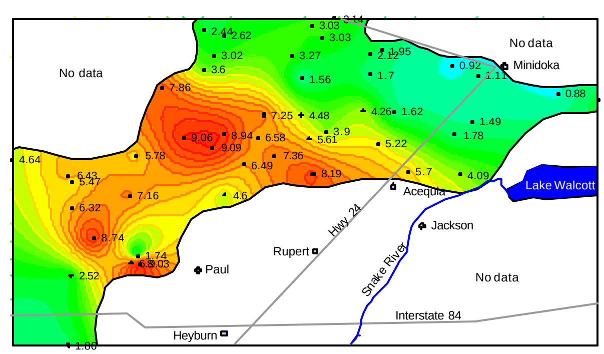

1997 ground water $NO_3$-N concentrations for the ESRP Aquifer (mg/L).



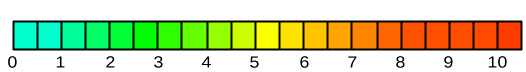

1998 ground water $NO_3$-N concentrations for the ESRP Aquifer (mg/L).




1999 ground water $NO_3$-N concentrations for the ESRP Aquifer (mg/L).




2000 ground water $NO_3$-N concentrations for the ESRP Aquifer (mg/L).




Nitrate Concentration Values (mg/L)

**Figure 5.** $NO_3$-N concentrations for the north Minidoka County basalt aquifer, 1997-2000.

elevated $NO_3$-N concentrations on Figure 5 correspond with previous $NO_3$-N level mapping done in the project area by Mitchell (1998). The elevated concentrations of $NO_3$-N correspond to a geographic area where soils transition from somewhat poorly drained sand, silty clay loams, and clay loams to well drained sand, silty clay loams, and silt loams. Well drained soils along with increasing sand and decreasing clay content correlate with increasing $NO_3$-N concentrations (Rupert, 1997). Areas north of Paul and Rupert may be vulnerable to elevated ground water $NO_3$-N concentrations because of the soil characteristics. Agricultural waste water injection wells are located in the vicinity of elevated ground water $NO_3$-N concentrations. Mixing of shallow ground water from the south with the deeper ESRP Aquifer is believed to occur in this area.

## Pesticides

Pesticide samples have been collected every other year, starting with 1997. Samples collected in 1997 were sent to the Washington Department of Ecology (WDOE) Laboratory in Manchester, Washington for pesticide analysis. Testing for pesticides was accomplished utilizing EPA Methods 1618 and 8085 with very low detection limits. In 1999, the pesticide samples were sent to the University of Idaho Analytical Sciences Laboratory (UIASL) in Moscow, Idaho. Samples were tested for various pesticides utilizing EPA Methods 507, 508, 515.1 and 531.1.

Pesticides were detected in numerous wells throughout the project area, however the detections were very low in concentration. Ground water samples collected during 1997 had positive detections of atrazine, atrazine desethyl, simazine, 2,4-D, bentazon, metribuzin, benzene, bromacil, diuron, carbaryl, and diazinon (See Table 2). All pesticide detections were below all health standard limits set by the EPA and the state of Idaho.

In 1999, two pesticides were positively detected in ground water samples. Simazine was detected in 12 wells and atrazine was detected in 10 wells (Table 3). The high values for simazine and atrazine were 0.098 micrograms per liter (µg/L) and 0.068 µg/L, respectively. All pesticide detections were again below all health standard limits set by the EPA and the state of Idaho. Fewer detections occurred in 1999 versus 1997 due to higher environmental detection limits utilized by the UIASL.

## Nitrogen Isotopes

### *Overview*

The ratio of the common nitrogen isotope $^{14}N$ to its less abundant counterpart $^{15}N$ relative to a known standard (denoted $\delta^{15}N$) can be useful in determining sources of $NO_3$-N. Common sources of $NO_3$-N in ground water are applied commercial fertilizers, animal or human waste, precipitation, and organic nitrogen within the soil. Each of these $NO_3$-N source categories has a distinguishable nitrogen isotopic signature. Figure 6 shows ranges of

**Table 2.** Pesticide results for North Minidoka regional project, 1997.

| Pesticide Detects | Number of Detects (48 Wells Sampled) | Range (µg/L) | Median Value of Detects (µg/L) | Health Standard (µg/L) |
|---|---|---|---|---|
| 2, 4-D | 5 | 0.0074 - 0.065 | 0.034 | 70 (MCL)* |
| Atrazine | 31 | 0.002 - 0.036 | 0.013 | 3 (MCL)* |
| Atrazine Desethyl | 30 | 0.002 - 0.048 | 0.013 | 35 (RfD)** |
| Bentazon | 4 | 0.0017 - 0.0074 | 0.0051 | 300 (RfD)** |
| Benzene | 2 | 0.007 - 0.40 | 0.20 | 5 (MCL)* |
| Bromacil | 2 | 0.007 - 0.32 | 0.16 | 100 (RfD)** |
| Carbaryl | 1 | 0.14 | 0.14 | 700 (HAL)*** |
| Diazinon | 1 | 0.02 | 0.02 | 0.09 (RfD)** |
| Diuron | 2 | 0.03 - 0.10 | 0.07 | 9 (RfD)** |
| Metribuzin | 4 | 0.003 - 0.006 | 0.005 | 13 (RfD)** |
| Simazine | 21 | 0.001 - 0.064 | 0.013 | 4 (MCL)* |

**Table 3.** Pesticide results for North Minidoka regional project, 1999

| Pesticide Detects | Number of Detects (48 Wells Sampled) | Range (µg/L) | Median Value of Detects (µg/L) | Health Standard (µg/L) |
|---|---|---|---|---|
| Atrazine | 10 | 0.034 - 0.068 | 0.043 | 3 (MCL)* |
| Simazine | 12 | 0.042 - 0.098 | 0.056 | 4 (MCL)* |

* MCL - EPA Maximum Contaminant Level
** RfD - EPA Reference Dose for 10 kg Child
*** HAL - EPA Health Advisory Level

$\delta^{15}N$ determined through numerous research studies. The graph displays the number of samples tested (y-axis) as compared to $\delta^{15}N$ results (x-axis) for various nitrogen sources. Typical $\delta^{15}N$ ranges for fertilizer is –5 to +5, while typical waste sources have ranges greater than 10, as seen on Figure 6. $\delta^{15}N$ values between 5 and 10 are generally believed to indicate an organic or mixed source.

Use of nitrogen isotopes as the sole means to determine nitrate source should be done with great care. $\delta^{15}N$ values in ground water can be complicated by several reactions (e.g., ammonia volatilization, nitrification, denitrification, plant uptake, etc.) that can modify the $\delta^{15}N$ values (Kendall and McDonnel, 1998). Furthermore, mixing of sources along shallow flowpaths makes determination of sources and extent of denitrification very difficult (Kendall and McDonnel, 1998).

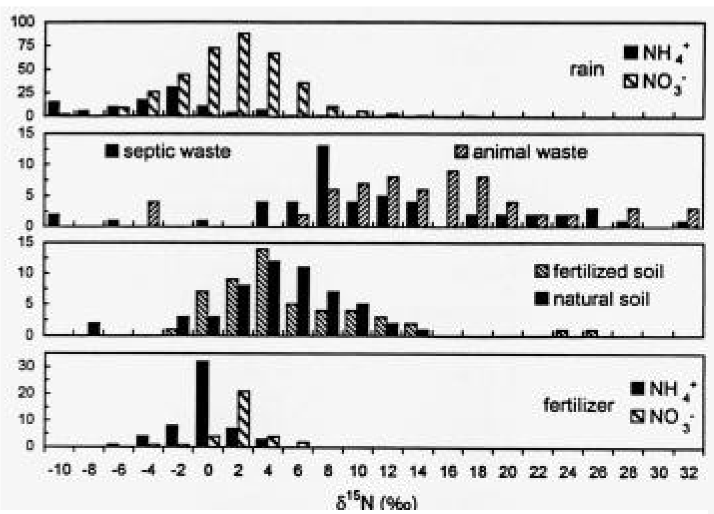



**Figure 6.** Ranges of $\delta^{15}N$ found in the hydrosphere based on a number of nitrogen isotope studies (after Kendall and McDonnel, 1998.

*Findings*

In 2000, ISDA chose to conduct $\delta^{15}N$ testing in order to use it as a possible indicator of source(s) of $NO_3$-N in the ground water. Because of the cost of testing and limited resources, only 8 of the wells in the area were selected for testing. Wells chosen for nitrogen isotope testing had previous nitrogen concentrations between 5 and 10 mg/L and are spatially distributed over the project area.

Results of $\delta^{15}N$ testing in 2000 returned values that ranged from $4.08^{0}/_{00}$ (per mil, or per thousand) to $11.41^{0}/_{00}$ (Table 4). Three wells (wells 22, 41, and 51, Figure 3) had values that were within the fertilizer range for $\delta^{15}N$. Wells 22 and 41 (Figure 3) are located northeast of Rupert, and correspond with the elevated levels of nitrate shown on Figure 5. Well 51 (Figure 3) is located northeast of Paul, which is also located in an area of elevated nitrate concentrations in Figure 5. Well 02 tested above $10^{0}/_{00}$, which is in the animal waste source range. The rest of the 4 wells sampled tested between 5-$10^{0}/_{00}$, indicating an organic or mixed source of nitrates.

**Table 4.** 2000 $\delta^{15}N$ results for selected wells.

| Well ID | $\delta^{15}N$ ($^{0}/_{00}$) |
|---|---|
| 7400101 | 6.33 |
| 7400201 | 11.41 |
| 7401501 | 6.76 |
| 7401701 | 7.28 |
| 7402201 | 4.35 |
| 7403201 | 7.20 |
| 7404101 | 4.60 |
| 7405101 | 4.08 |

# Conclusions

Ground water within the Eastern Snake River Plain Aquifer is being impacted by $NO_3$-N and pesticides within Minidoka county. The continued increase of the median $NO_3$-N concentration from 1997-2000 is of concern. Pesticide detections were low in concentration; however, there is concern about multiple pesticide detections per sampling well. Little is understood about the health effects of consuming low quantities of multiple pesticides.

The number of wells exceeding 5 mg/L $NO_3$-N is of concern. In 1997, 1998, and 2000 42% of the 48 wells sampled had nitrate concentrations over 5 mg/L. No wells exceeded the EPA drinking water standard of 10 mg/L. Northwest of Paul and northwest of Rupert are areas of concern because of elevated $NO_3$-N concentration clusters in those areas. The majority of wells sampled are between 150-300 feet deep.

Although the number of pesticide detections apparently decreased from 1997 to 1999, this is likely a function of the laboratory detection methods used. In 1997, over half of the wells tested had positive pesticide detections. Eleven different pesticides were detected in 1997 with atrazine and atrazine desethyl detections the most common. In 1999, atrazine and simazine were the only two pesticides detected. One or both of these pesticides were detected in 31% of the wells.

$\delta^{15}N$ test results returned three ground water samples that suggest a fertilizer influence. One sample test result suggests an animal waste source. Half (four) of the sample results suggest an organic or mixed source.

Agricultural practices contribute to $NO_3$-N and pesticide detections in the ground water of this project area. Test results indicate $NO_3$-N and pesticide impacts to ground water in the project area are widespread. Rupert (1996) calculated that 93% of total nitrate input into the ESRP regional system is supplied by cattle manure (29%), fertilizer (45%), and legume crops (19%). The soil in the project area drains well to excessively. Well draining soil most strongly correlates to high concentrations of $NO_3$-N in the ground water (Rupert, 1997). Leaching of applied commercial fertilizers is probably a major cause of $NO_3$-N entering the ground water because the soil drains irrigation water rapidly. Mixing of nearby shallow ground water with the deeper ESRP aquifer system may be contributing $NO_3$-N and pesticides to the deeper system. Injection well inputs to the ground water are also a source of concern in the project area.

## Recommendations

To determine how current farming practices are contributing to ground water degradation and to locate other potential contaminate sources, the ISDA recommends continued and more intensive monitoring in the project area. Testing should include, but not be limited to:

- Continued ground water monitoring for nutrients, common ions, and pesticides.
- Continued isotope testing to determine possible nitrate sources and relative ages of ground water.
- Soil sampling and soil pore water sampling.
- Idaho Department of Water Resources (IDWR) conducting comprehensive monitoring and regulation of injection wells.

The ISDA further recommends that measures to reduce nitrate and pesticide impacts on the ground water be addressed and implemented. The ISDA recommends that:

- Growers and agrichemical professionals conduct nutrient, pesticide, and irrigation water management evaluations.
- Producers follow the Idaho Agricultural Pollution Abatement Plan and Natural Resources Conservation Service Nutrient Management Standard.
- Producers and agrichemical dealers evaluate their storage, mixing, loading, rinsing, containment, and disposal practices.
- Homeowners assess lawn and garden practices, especially near wellheads.
- Local residents assess animal waste management practices.
- State and local agencies assess impacts from private septic systems.
- Home and garden retail stores establish outreach programs to illustrate proper application and management of nutrients and pesticides.
- Responsible parties assess current pesticide application practices to non-crop areas (examples: roadsides, railroads areas, etc).

The ISDA recommends that the Minidoka Soil and Water Conservation District lead a response process to create a plan of action to address these ground water contamination issues. The soil and water conservation districts should work with local agrichemical professionals, landowners, and agencies to implement this process and seek funding to support these efforts. The ISDA will support these local partners in seeking funding and implementing a comprehensive program.

## References

Bendixsen, S., 1996. Burley-Rupert Area—Idaho Department of Water Resources Poster, Boise, Idaho 83706.

Davis, L., and Larson, J., 1998. Unpublished Map of the Eastern Snake River Plain, Idaho Department of Water Resources, Boise, Idaho Office.

Hansen, Harold L., 1975. Soil Survey of Minidoka Area, Idaho, Parts of Minidoka, Blaine, and Lincoln Counties. United States Department of Agriculture, Soil Conservation Service, Map 1.

Kendall, C., and McDonnell, J.J., 1998. Isotope Tracers in Catchment Hydrology. Elsevier Science B.V., Amsterdam. pp. 519-576.

Lindholm, G.F., Garabedian, S.P., Newton, G.D., and Whitehead, R.L., 1983. Configuration of the Water Table, March 1980, in the Snake River Plain Regional Aquifer System, Idaho and Eastern Oregon. Geological Survey, Boise, Idaho, Water Resources Division, 1 p.

Mitchell, John C., 1998. Waste Disposal Wells as a Factor in Nitrate Levels in Ground Water, A&B Irrigation District, Minidoka County, Idaho. Idaho Department of Water Resources, 2 p, 1-6 maps.

Neely, K. W., and Crockett, J. K., 1999. Nitrate in Idaho's Ground Water: Idaho Department of Water Resources Technical Results Summary No. 1, 1 p.

Rupert, M.G., 1996, Major Sources of Nitrogen Input and Loss in the Upper Snake River Basin, Idaho and Western Wyoming, 1990: U.S. Geological Survey Water Resources Investigations Report 96-4008, 15 p.

Rupert, M.G., 1997. Nitrate ($NO_2$+$NO_3$-N) in Ground Water of the Upper Snake River Basin, Idaho and Western Wyoming, 1991-95. U.S. Geological Survey, pp. 3-8, 12, 20, 26, 42.